www.ThePharmaJournal.com
The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2019; 8(5): 307-310

www.thepharmajournal.com
Received: 22-03-2019
Accepted: 23-04-2019

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Effect of soil application of calcium and boron on yield and post-harvest quality of apple (CV. Royal Delicious)

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Abstract
The experiment was conducted during the year 2008-2009 and 2009-2010 on Gopalpora horticultural nursery of district budgam, Jammu and Kashmir. Twenty healthy trees of apple (CV Royal delicious) of uniform size, Age, and vigour were selected from the orchard site for experimental purpose. Three levels each of calcium (90gm, 110gm and 130gm) and boron (8gm, 10gm and 12gm) were applied during the early spring 15 days prior to bloom on the selected trees to ascertain the effect of soil application of calcium and boron on yield and physi-co-chemical characteristics of apple (CV. Royal delicious). Significant differences were observed among the treatments for all the physical and chemical characteristics studied. Soil application of calcium and boron significantly influenced the yield and post-harvest quality of Royal delicious apple cultivar. Among the treatments Soil application of 110gm of calcium+ 10gm of boron (C2B2) recorded highest average fruit yield (19.85 Kg), average fruit diameter (68.08 mm), T.S.S (11.05^0 Brix), Total sugar (9.59%), besides % age increase in yield over control treatment (C0B0), whereas ascorbic acid content was recorded highest (7.13mg/100g) in C1B2(90gm calcium+10gm boron). Based on observations recorded treatment C2B2 was found to be most effective treatment in improving the growth, yield and post-harvest quality characteristics of apple cv. Royal delicious. The present study confirms the feasibility of the treatment (C2B2) as soil application for better yield and post-harvest quality of apple and should be applied at least 15 days prior to bloom for best results.

Keywords: Apple, physi-co-chemical, quality, yield, soil application

1. Introduction

Apple (*Malus domestica* Borkh.) is a highly appreciated fruit grown in many countries of the world and economically, it is the fourth most important fruit crop after citrus, grapes and banana (Affzadi, 2014) [1]. The total area under apple cultivation in the world is 4860010 hectares with an annual production of more than 68.60 million Tons (Anon, 2018) [2]. China is the leading producer of apples in the world with an annual production of 31 million Tons followed by European union, United States, Turkey and Italy (Anon, 2018) [2]. India is the sixth largest producer of apples in the world. In India, the total area under apple cultivation is 2 lakh hectares with an overall production of 23 lakh metric tons which accounts for 3.30% of the total worlds production (Anon, 2018) [2]. Jammu and Kashmir is the major apple producing state accounting for more than 70 percent of the total apple production in the country and the production per hectare is 10.25 metric tons, which is higher than the national average of 7.98 Metric tons (Islam and Shrivastava, 2017) [3]. Therefore, apple trade is important for economic growth of the state and hence a substantial foreign exchange earner (Malik and Choure, 2014) [4]. The quality of an apple depends on its physical and visual characteristics and chemical composition. The quality attributes undoubtedly are affected differentially by these factors, so the effects of these factors need to be recognized and understood so that growing and handling conditions that will result in apples of excellent quality can be delineated and recommended. Fruit quality usually improves as soil moisture and nutrients increase from deficient to optimum that also maximizes the yield component (Tyagi *et al.*, 2017) [6]. Poor management of fertilizers will induce physiological disorders due to deficiency of some nutrients or increase of other leading to toxicity. The storage life of apple is effected not only by handling conditions and storage environment but to a great extent by preharvest factors such as genetic, nutrition, environmental, cultural and their interactions (Kader, 1983) [6]. Calcium plays a key role in a wide range of physiological process. The role of calcium is well known as a constituent of cell wall in the form of calcium pectate. Its role has also been implicated in guard cell physiology and certain enzymes are activated by calcium.

The immobility of calcium has perhaps the most practical importance. Many physiological disorders e.g. bitter pit, cork spot, internal break down etc. are associated with low calcium levels. Boron plays a significant role in pollen germination and pollen tube growth in deciduous fruit trees. Boron is essential for carbohydrate metabolism as it helps in translocation of sugars and synthesis of DNA in the meristem. Boron deficiency causes cracking and internal and external cork development in fruit. In addition to relieving boron deficiency symptoms, boron application may effect fruit quality through its effect on fruit calcium nutrition. Application of boron to apple trees low in boron was shown to increase mobility of Ca in the tree. A survey conducted in District budgam of Jammu and Kashmir state by Krishi Vigyaan Kendra Budgam, SKUAST-K revealed high incidence physiological disorders like fruit deformation, bitter pit, water core, low keeping quality after harvest and poor consumer acceptability which was prevalent among various pockets of the district, besides low yield of fruit trees especially on cultivar Royal delicious on account of poor nutrient management with respect to application of calcium and boron. Keeping in view the above problems reported by the farmers. It was decided to conduct an on farm trial with the following objectives.

1. To study the effect of soil application of calcium and boron on yield of apple (CV. Royal delicious)
2. To study the effect of calcium and boron on post-harvest quality of apple (CV. Royal delicious)

2. Material and methods

The experiment was conducted during the on Gopalpora horticultural nursery of district budgam, Jammu and Kashmir with the intervention of KVK budgam, SKUAST-K. Twenty healthy trees of apple (Cv Royal delicious) of uniform size, Age and vigour were selected from the orchard site for experimental purpose. Three levels each of calcium (90gm, 110gm and 130gm) and boron (8gm, 10gm and 12gm) were applied during the early spring 15 days prior to bloom on the selected trees in nine treatment combinations and two replications with each tree acting as unit of replication along with control treatment. The treatment combinations were as follows.

C1B1 90gm calcium+8gm boron
C1B2 90gm calcium+10gm boron
C1B3 90gm calcium+12gm boron
C2B1 110gm calcium+8gm boron
C2B2 110gm calcium+ 10gm boron
C2B3 110gm calcium+ 12gm boron
C3B1 130gm calcium+ 8gm boron
C3B2 130gm calcium+ 10gm boron
C3B3 130 gm calcium + 12gm boron
C0B0 No calcium and boron application.

Standard cultural practices were followed during the entire study conducted over the period of two years. The fruits were harvested at physiological maturity during autum season and were evaluated for physi-co-chemical characteristics viz., Average fruit yield (Kg) Average fruit diameter (mm), Total soluble solids (^{0} Brix), Acidity (% maleic acid), Total sugar (%), ascorbic acid (mg/100gm) and % age increase over yield. The data on physico-chemical parameters was recorded over the period of two tears and mean value for each parameter was arrived at. The whole experiment was laid out in randomized block design with two replications.

2.1 Average fruit yield (Kg): Average fruit yield per tree was calculated by harvesting all the fruits from the tree and then weighing them accurately on electronic balance and was expressed in kg.

2.2 Average fruit diameter (mm): The breadth of the fruits from ten randomly selected samples in triplicate of each treatment was measured from the longest dimension perpendicular to the length by Vernier caliper as described by Torabi *et al.* (2013) [7]. Average values were calculated and expressed in mm.

2.3 Total soluble solids (^{0}brix): Total soluble solids (TSS) were determined for each sample fruit in two replications using an Atago DR-A1 digital refractometer (Atago Co. Ld., Japan) at 20 °C and expressed as °Brix.

2.4 Titrable acidity (%): The titratable acidity was estimated by titrating 5 ml of sample against 0.1N NaOH solution using phenolphthalein as an indicator. The acidity was calculated and expressed as per cent anhydrous malic acid (FAO, 2001) [8].

2.5 Total sugar (%): Total sugars were determined by the methods described by Ranganna (1986) [9] with slight modifications. To a known quantity of sample (10 ml or 10 g), 10 ml of 45% lead acetate solution was added and after 15 to 20 min, 5 g potassium oxalate was mixed. The content was filtered through Whatman No. 41 filter paper and the volume of the filtrate was made up to 100 ml with water. 75 ml of this filtrate was titrated against Fehling’s solutions A and B (5 ml each) using methylene blue as indicator. The remaining 25 ml filtrate was mixed with 5 ml conc. HCl and kept overnight. It was then, neutralized with 10% NaOH solution using phenolphthalein as an indicator. The volume of this pink coloured solution was made up to 75 ml and then, titrated against Fehling’s solutions A and B (5 ml each).

$$\text{\% Total sugar (as invert sugars)} = \frac{0.05 \times V_1 \times V_2 \times 100}{T_2 \times W \times 25}$$

Where,
V_1 = Volume of the extract made up to 100 ml,
V_2 = volume made up after neutralization,
T_1 = 1st titre value;
T_2 = 2nd titre value,
W = weight of sample taken

2.6 Ascorbic acid (mg/100g): Ascorbic acid was estimated by the method as described by Rangana (1986) [9] using 2, 6-dichlorophenol indophenol dye. Dye factor was calculated by titrating 5 ml standard ascorbic acid plus 5 ml (3%) metaphosphoric acid against 2, 6-dichlorophenol indophenol till pink colour appeared and volume used was noted.

$$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

5g of sample was taken and volume was made upto 100 ml with (3%) metaphosphoric acid and filtered. Then aliquot of 10 ml was taken in a titration flask and titrated against 2, 6-

dichlorophenol indophenol till light pink colour appeared (which persisted for 15 seconds). Vitamin C was calculated using the following formula:

$$\text{Ascorbic acid (mg/100g):} \frac{\text{Titre value} \times \text{dye factor} \times \text{volume made up}}{\text{ml of filtrate taken for} \times \text{weight of sample estimation}} X\ 100$$

3. Result and Discussion

3.1 Effect of soil application of calcium and boron on physi-co-chemical characteristics of Apple (CV. Royal delicious)

3.1.1 Physical characteristics

The effect of soil application of calcium and boron on physical characteristics of apple has been presented in the Table 1. Significant differences were observed among all the treatments for all the physical characteristics under study. Mean fruit yield from two years data was found significantly higher (19.95 kg) in case of treatment C1B2 (90gm calcium+10g boron application) where as it was recorded lowest in the control treatment (C0B0). Further it was observed all other treatments exhibited their superiority over the control treatment. Data with respect to average fruit diameter as depicted in the table 1 indicated that soil application of 90 grams of calcium and 10grams of boron (C1B2) significantly improved the mean average diameter of apple fruits of cultivar Royal delicious (67.95 mm) over the control treatment (C0B0) where the mean average fruit diameter was recorded lowest (56.08mm). This indicated that soil application of calcium and boron had significant impact on yield and growth of the apple fruits. Further % increase of yield over control treatment (C0B0) was also recorded highest in C1B2 (73.32 %) followed by C3B3 (130 gm calcium+12gm boron application). Pre harvest application of calcium and boron at lower concentration has been reported to significantly improve the yield and size of apple fruits as has been reported by various workers (Mir *et al.,* 1996; Kilany and Kilany, 1991) [10, 11] which are consisten with the present findings. Similar results have been reported by Mehta and Jindal (1986) in plum and wani (1997) [12, 13] in peach.

3.1.2 Chemical Characteristics

The effect of soil application calcium and boron on chemical characteristics of apple (CV. Royal delicious) has been presented in the Table 1. Significant differences were observed among the treatments for all the chemical characteristics studied. Average mean T.S.S (^{0}Brix) from two years experimental data was recorded significantly highest (11.05^0 brix) in treatment C2B2 (110 gm calcium+ 10gm boron) while as it was recorded lowest (7.00^0 brix) in case of control treatment (C0B0) indicating that intermediate level concentration of calcium and boron increased the total soluble solid concentration. Further increase in the calcium and boron reported a significant decrease of total soluble solids in rest other treatments. Higher T.S.S reported by application of calcium and boron might be due to lesser utilization of sugars in metabolic process as a result of reduced respiration (Gupta *et al.,* 1980) [14]. Similar results were reported by Raese and Drake (1993) [15] in apple which corroborate with our findings. Data with regard to acidity (%) of the apple fruits indicated the mean acidity was significantly highest (0.37) in control treatment (C0B0) where no calcium and boron was applied to the soil whereas as it was recorded lowest (0.20) in C2 B2 (110gm calcium + 10 gm boron). Acidity. Lowest titrable acidity of apple fruits from treatment C2B2 corresponds to the highest total sugar concentration of the said treatment. This can be attributed to translocation of carbohydrates due to application of calcium and boron and effect being more pronounced in C2B2 because of its highest total sugar percentage (Davenport and Pareyea, 1990) [16]. This indicated that increase in total sugar content was directly related to decrease in acidity. Bhat and Farooqi *et al*. (2004) [17] reported similar findings on red delicious apple cultivar. Data with regard to total sugar content depicted significantly higher total sugar (9.59%) content in apple fruits treated with C2B2 whereas lowest (5.98) total sugar percentage was recorded in control (C0B0). This can be attributed to increased translocation of carbohydrates with the application of boron (Davenport and Pareyea, 1990) [16]. Further pre harvest application of calcium and boron was also found to significantly influence the amount of ascorbic acid accumulated by the fruit tissue. As seen from the table 1 mean ascorbic acid content was significantly higher (7.13 mg/100gm) in case of treatment C1B2 (90gm calcium+10gm boron) which was found to be statistically at par with C2B2 (110gm calcium+ 10gm boron). While as it was recorded lowest (5.85) in control (C0B0). Further it was observed that all the treatments were found to improve the ascorbic acid content of the fruits with respect to control treatment. Increase in ascorbic acid content with application of calcium chloride has also been confirmed by various workers (Pant and Tewari, 1987; Bhat *et al.,* 1997) [18, 19] which are in line with the present findings. Besides none of the treatments showed any visual signs of post-harvest disorders (Data not shown) whereas there was marked decrease in the quality of control treated fruits with visible signs of bitter pit and flesh browning. The apple fruits from the treatments with highest concentration of boron and calcium showed (130gm calcium+12 gm boron) showed poor fruit colour and hard flesh when compared to other treatments when measured with fruit pressure tester (Data not shown).

4. Conclusion

So in view of above findings it can be concluded that treatment C2B2 (110gm of calcium and 10gm of Boron) was found to be effective in improving the yield and post-harvest quality of apple (cv. Royal delicious) and should be applied 15-20 days prior to bloom so as to extract maximum benefit form judicious application of these essential nutrients. It should be noted that Trails were conducted for a period of two years on a fixed experimental location at Gopal pora Horticulture Nursery using Ca and Boron form Tata Paras Chemicals Limited. But in the broader perspective experiment needs to be conducted on various locations of the District keeping in view the topography of land which includes low and high altitude karewas. Moreover pattern of plantation viz., high, medium and low density plantation needs to be kept in view to arrive at the optimum concentration of these essential nutrients for maximum benefit to the farmers and orchardists.

Table 1: Effect of soil application of calcium and boron on yield and post-harvest quality of apple (CV. Royal delicious)

Treatment	Avg. Fruit Yield (kg/tree)			Avg. Fruit Diameter (mm)			T.S.S (^{0}brix)			Acidity (%)			Total Sugar (%)			Ascorbic acid (mg/100gm)			% Increase in yield over control		
	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean
$C_1 B_1$	16.00	15.16	15.58	60.76	58.10	59.43	8.84	8.02	8.43	0.28	0.21	0.25	6.46	6.08	6.27	6.91	6.45	6.68	34.00	36.82	35.41
$C_1 B_2$	19.21	19.00	19.10	67.00	68.89	67.95	8.12	8.66	8.39	0.26	0.27	0.26	7.61	8.26	7.94	7.24	7.02	7.13	35.00	35.51	35.25
$C_1 B_3$	15.81	14.64	15.23	64.26	63.16	63.71	9.00	8.21	8.61	0.26	0.28	0.27	7.31	7.46	7.39	6.81	6.62	6.72	33.30	32.13	32.72
$C_2 B_1$	16.16	15.67	15.92	60.33	58.29	59.31	9.23	9.00	9.12	0.27	0.25	0.26	6.48	6.16	6.32	6.61	5.97	6.29	36.25	41.43	38.84
$C_2 B_2$	19.79	19.92	19.85	68.00	68.16	68.08	10.89	11.21	11.05	0.21	0.19	0.20	9.76	9.43	9.59	6.92	6.88	6.90	66.86	79.78	73.32
C2 B_3	17.96	18.00	17.98	63.00	64.00	63.50	9.00	9.05	9.03	0.30	0.27	0.28	7.21	7.03	7.12	6.81	6.63	6.72	51.43	62.45	56.94
C3 B_1	16.79	16.56	16.68	63.00	62.43	62.72	9.26	9.31	9.29	0.27	0.30	0.28	7.08	6.85	6.97	6.53	6.69	6.61	41.56	49.46	45.51
C3 B2	17.68	18.01	17.85	62.66	63.54	63.10	8.81	8.92	8.87	0.33	0.34	0.34	6.49	6.32	6.41	6.46	6.14	6.30	49.07	62.55	55.81
C3 B_3	17.96	18.24	18.10	61.86	62.40	62.13	8.43	8.96	8.70	0.29	0.33	0.31	7.81	7.69	7.75	6.19	5.96	6.08	51.43	64.62	58.03
$C_0 B_0$ (control)	11.86	11.08	11.47	55.49	56.67	56.08	7.10	6.89	7.00	0.35	0.39	0.37	6.10	5.86	5.98	5.90	5.79	5.85	-	-	-
CD ($P \leq 0.05$)	-	-	1.962	-	-	3.896	-	-	2.106	-	-	0.018	-	-	1.103	-	-	0.391	-	-	15.94

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